

UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

Cocoanut Meal as a Feed for Dairy Cows and Other Livestock

BY
F. W. WOLL

BULLETIN No. 335

NOVEMBER, 1921

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY, CALIFORNIA

DAVID P. BARROWS, President of the University.

EXPERIMENT STATION STAFF

HEADS OF DIVISIONS

THOMAS FORSYTH HUNT, Dean.
EDWARD J. WICKSON, Horticulture (Emeritus).
———, Director of Resident Instruction.
C. M. HARING, Veterinary Science, Director of Agricultural Experiment Station.
B. H. CROCHERON, Director of Agricultural Extension.
JAMES T. BARRETT, Plant Pathology, Acting Director of Citrus Experiment Station.
HUBERT E. VAN NORMAN, Dairy Management.
WILLIAM A. SETCHELL, Botany.
MYER E. JAFFA, Nutrition.
RALPH E. SMITH, Plant Pathology.
JOHN W. GILMORE, Agronomy.
CHARLES F. SHAW, Soil Technology.
JOHN W. GREGG, Landscape Gardening and Floriculture.
FREDERIC T. BIOLETTI, Viticulture and Fruit Products.
WARREN T. CLARKE, Agricultural Extension.
ERNEST B. BABCOCK, Genetics.
GORDON H. TRUE, Animal Husbandry.
WALTER MULFORD, Forestry.
FRITZ W. WOLL, Animal Nutrition
W. P. KELLEY, Agricultural Chemistry
H. J. QUAYLE, Entomology
ELWOOD MEAD, Rural Institutions
H. S. REED, Plant Physiology
L. D. BATCHELOR, Orchard Management.
J. C. WHITTEN, Pomology
*FRANK ADAMS, Irrigation Investigations.
C. L. ROADHOUSE, Dairy Industry.
R. L. ADAMS, Farm Management
W. B. HERMS, Entomology and Parasitology.
F. L. GRIFFIN, Agricultural Education
JOHN E. DOUGHERTY, Poultry Husbandry.
D. R. HOAGLAND, Plant Nutrition.
G. H. HART, Veterinary Science.
L. J. FLETCHER, Agricultural Engineering.
EDWIN C. VOORHIES, Assistant to the Dean.

DIVISION OF ANIMAL HUSBANDRY

G. H. TRUE	J. F. WILSON
F. W. WOLL	E. C. VOORHIES
R. F. MILLER	G. H. WILSON
E. E. HUGHES	W. E. TOMSON
C. E. HOWELL	ARTHUR FOLGER

* In coöperation with office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

COCOANUT MEAL AS A FEED FOR DAIRY COWS AND OTHER LIVESTOCK

By F. W. WOLL

Cocoanut meal is commonly fed to dairy cows in California and also, to some extent, to beef cattle, hogs, and poultry—to the last class of farm animals as a component of commercial mixed feeds. During the past half-dozen years, the quantities of cocoanut meal sold in the State have increased enormously, owing to war conditions which closed the European market for the raw material from which it is made, thus preventing the manufacture of the meal there and its utilization for stock feeding.

Cocoanut meal is likely, as the years go by, to retain the important position among our available feeding stuffs which it has reached, and even to increase in importance. It seems desirable, therefore, to furnish some detailed information as to the origin of this oil meal and its value and use in feeding different classes of live stock, in order that our farmers generally may become acquainted with both its good and its less desirable qualities, and may use it in their feeding operations whenever its cost makes it economical in comparison with other valuable stock feeds. Hence this bulletin has been prepared, covering the subjects stated and also including the results of recent feeding experiments with cocoanut meal at the University Farm in which its special value as a component of grain rations for dairy cows was studied.

Origin.—Cocoanut meal is a by-product of the manufacture of cocoanut oil from copra, the dried, broken pieces of cocoanut meats. Cocoanuts are the fruit of the cocoanut palm (*Cocos nucifera*), which is grown extensively in coastal regions of the tropics, especially in the East Indies, Australia, the Philippines and other islands in the Pacific Ocean, and in South America and Africa. Its culture in these regions has greatly increased during recent years.

The raw copra is either imported as such into the Pacific Coast ports, mainly San Francisco, or is manufactured abroad into cocoanut cake from which the meal is obtained by grinding. The following figures show the total importations of each article into San Francisco, Los Angeles, Portland, and Seattle, 1915 to 1920.

IMPORTATIONS OF COPRA AND COCOANUT CAKE INTO PACIFIC COAST PORTS,
1915-1920

	Copra in tons	Cocoanut cake in tons
1915	38,385	
1916	46,416	
1917	103,790	
1918	198,188	
1919	121,353	5,308
1920	99,632	59,073

The cocoanut palm furnishes three important articles of commerce : the fiber obtained from the outer shell of the nut, the copra, and the oil. The oil makes up from one-half to two-thirds of the dried copra, according to the degree of ripeness of the nuts; it is removed by pressure or by extraction, leaving a residue in the form of slabs or cakes about three-fourths of an inch thick. These are usually ground into a meal before being sold for stock feeding; sometimes, however, they are simply broken into pieces about the size of walnuts and in that form fed to the stock. Fresh cocoanut meal has a pleasant aromatic, nutty flavor, and is of a light gray to brownish color. It is, as a rule, much relished by cattle and sheep, and is also used for feeding other farm stock. It differs in chemical composition from our other common oil meals, such as linseed or cottonseed meal, in that it contains considerably less protein and, usually, more fat than they contain. In composition it resembles more closely gluten than any of the other concentrates, and in its feeding value is considered of similar rank with that important eastern dairy feed.

Chemical Composition.—The chemical composition of cocoanut meal varies considerably according to the quality of the raw material used and the method of manufacture, especially with reference to the extent to which the oil is removed in the manufacturing process. The following table gives the average composition, with ranges in different components, of seventeen samples of cocoanut meal analyzed during the last few years in the chemical laboratories of the Division of Nutrition of the University of California and the State Bureau of Foods and Drugs.

CHEMICAL COMPOSITION OF COCOANUT MEAL, IN PER CENT		
	Average	Ranges
Moisture	10.55	6.9-15.7
Protein	20.69	18.5-22.4
Fat	8.78	6.5-10.7
Fiber	9.60	5.7-14.7
N-free extract	44.41	39.6-49.5
Ash	5.97	5.1- 7.0
	100.00	

It will be noted that the protein content of the cocoanut meal found on the market at the present time is close to 20 per cent, ranging from 18 per cent to over 22 per cent, while the fat content ranges from 6 per cent to over 10 per cent (average about 8 per cent). Analyses of imported meal containing over 20 per cent fat are occasionally met with, however, making fat the most variable component of the meal. The fiber content ranges from 6 per cent to nearly 15 per cent.

Digestibility.—The digestibility of cocoanut meal has been determined by several investigators in experiments with sheep, steers, and pigs. The results have shown the percentage digestibility of the various components to vary as follows:

DIGESTIBILITY OF COCOANUT MEAL, WITH VARIATIONS, IN PER CENT

	Ranges	Average
Dry matter	75- 90	82
Crude protein	75- 90	85
Fat	96-100	98
Fiber	23- 73	50
Nitrogen-free extract (starch, etc.)	80- 87	83

These results show that cocoanut meal has a very high digestibility, ranking well up with the other oil meals and the cereal grains in this respect, and considerably above the flour-mill feeds and other factory by-products.

Figures for the total digestible components of cocoanut meal are given in the following table, in which are also included, for the sake of comparison, a few concentrates common in this State—cottonseed meal, barley, wheat bran, and dried beet pulp.

DIGESTIBLE COMPONENTS OF COCOANUT MEAL AND OTHER CONCENTRATES, IN PER CENT

	Cocoanut meal	Cottonseed meal	Barley	Wheat bran	Dried beet pulp
Dry matter	73.3	72.9	78.5	57.3	61.2
Protein	17.6	34.0	9.4	12.0	4.2
Fat	8.6	8.1	1.4	2.7	
Fiber	4.8	3.2	2.4	2.8	14.5
Nitrogen-free extract (starch, etc.)	36.8	20.8	63.2	38.8	50.5
Ash	3.8	4.2	1.0	1.8	1.2
Digestible carbohydrates and fat	61.0	42.2	69.8	47.7	65.0
Nutritive ratio, 1:	3.5	1.2	7.4	4.0	15.5

Cocoanut meal, as found on the market at the present time, has a higher percentage digestibility and contains more total digestible

nutrients than wheat bran or dried beet pulp, and ranks close to cottonseed meal and barley, both in digestibility and in total nutritive components. Its content of digestible protein is higher than that in the other feeds given, except cottonseed meal. It compares well with barley and dried beet pulp in content of digestible carbohydrates and fat, and in this respect exceeds both cottonseed meal and wheat bran by 15 to 20 per cent. The nutritive ratio of cocoanut meal, while wider than that of cottonseed meal, our most concentrated protein feed of vegetable origin, is close to that of wheat bran and considerably narrower than that of barley or beet pulp. In other words, cocoanut meal has a relatively higher percentage of digestible protein than all these feeds except cottonseed meal, and is therefore well adapted to supplement starchy feeds, like the cereal grains and beet pulp, or most medium protein feeds, like wheat bran, middlings, or shorts, in compounding rations for farm stock.

Net Energy Values.—Another method of expressing the comparative nutritive value of feeding stuffs is afforded by the use of the energy values worked out during recent years by leading investigators, in this country mainly by Armsby, of Pennsylvania. The figures for the net energy values of the concentrates given above are, in decreasing order, cottonseed meal, 90.0; ground barley, 89.9; linseed meal, 88.9; cocoanut meal, 83.5; dried beet pulp, 75.9, and wheat bran, 53.0.¹ These figures indicate relative values substantially similar to those given above, which are based on the contents of digestible components in the different feeds.

Guarantees.—Cocoanut meal is generally sold in this State on a guarantee of a minimum crude protein content of 21 per cent, a minimum fat content of 6 per cent, and a maximum fiber content of 10 per cent. The contents of these components must be guaranteed under the State Feed Law, and purchasers should see to it that labels or sacks give printed guarantees and otherwise conform to the provisions of the law. In case of sale of meal of apparently inferior quality, or abnormal in any way, the matter should be reported promptly for investigation to the Director of the State Bureau of Foods and Drugs, Berkeley, who is charged with the enforcement of the Feed Control Law.

There is some difference of opinion in regard to the quality and value of the imported cocoanut cake or meal in comparison with the domestic material obtained as a by-product in the manufacture of cocoanut oil at Pacific Coast mills. A few shiploads of foreign

¹ Armsby, *The Nutrition of Farm Animals*, pp. 718-720.

cocoanut cake that were heavily infested with weevils have been received of late years, but this is as likely to occur with raw copra as with the cake or meal. Our present knowledge of the quality and chemical composition of cocoanut meal of different origins is not sufficiently complete to warrant an expression of opinion as to relative feeding values, or as to the relative economy of meal crushed in this country and that imported from different countries of the Orient.

Feeding Value.—As would be expected from its chemical composition and digestibility, cocoanut meal has a high feeding value and forms a valuable source of digestible protein, carbohydrates, and fat, as well as mineral matter, for feeding farm stock. Direct feeding experiments at the Massachusetts Experiment Station² have shown that it compares well in nutritive effect with gluten feed, one of the favorite feeds with the dairymen in eastern and central states. Experiments at the Florida and Texas stations have likewise furnished evidence as to its value in feeding dairy cows. The results of experiments at the former Station³ led to the conclusion that a unit of protein in cocoanut meal is very nearly, though not quite equal to a unit of protein in cottonseed meal, and, according to the Texas experiments,⁴ for dairy cows cocoanut meal is practically equal to cottonseed meal from the standpoint of the cost of producing milk and butter fat. Practical feeding experience in our own and other Pacific Coast states has shown that cocoanut meal is a good dairy feed, and may also be used to advantage in feeding hogs and poultry, either mixed with other concentrates or as a component of special commercial mixed feeds that are sold extensively for this purpose in this and other states.

In addition to being fed to the farm animals mentioned, cocoanut meal is used in continental Europe as a partial substitute for oats in rations for army and work horses, and is also fed to work horses in Australia. It appears to be well adapted to this purpose. As much as one-fourth of the grain ration of horses may be composed of this meal without any ill effects so far as the working capacity or the general well-being of the animals is concerned, and through its use the total cost of the rations fed is considerable reduced. These results have been corroborated in trials conducted by Rommel and Hammond, of the U. S. Department of Agriculture, at the Morgan Horse Farm in Vermont.⁵

² J. B. Lindsey, *Cocoanut Meal*, Bulletin 155, July, 1914.

³ Bulletin 99, July, 1909.

⁴ Bulletin 225, March 1918. See also South Carolina Exp. Sta. Report 1918, p. 25; California Sta. Bulletin 132, p. 18.

⁵ U. S. D. A., Bureau of Animal Industry, Circular 168. Feb., 1911.

Market Price.—The market prices of feeding stuffs have gradually decreased during the past year from those prevailing during and directly after the war period, until approximate pre-war prices have been reached by the present time. During a considerable part of last year, cocoanut meal was nearly \$20.00 cheaper per ton than wheat bran and over \$10.00 cheaper than rolled barley. During the first nine months of 1921, however, the difference in the cost of these feeds has been greatly reduced. The average San Francisco market prices in car-load lots of the feeding stuffs given during this period were as follows, per ton: Wheat bran \$35.08; rolled barley \$30.55; cocoanut meal \$25.39. Such large differences in cost will probably not continue very long, but manufacturers of cocoanut meal will most likely always be in a position to meet the competition of other feed manufacturers and, as previously suggested, this oil meal is well worth the attention of stock-men even when sold at similar prices as those which other common concentrates in this state command.

Palatability.—Cocoanut meal is, as a rule, very palatable to cattle, but less so to hogs and other farm animals. In any class of stock, individual animals, however, occasionally refuse to eat the meal, whether fresh or not; but, by a little coaxing, and by feeding only small amounts at first (about a quarter of a pound) mixed with feeds to which the animals are accustomed, the prejudice is generally easily overcome. When accustomed to the meal, dairy cows at least will eat it with relish in large amounts, sometimes as much as four to six pounds per head daily. In ordinary feeding practice, however, cows are not usually fed more than two or three pounds a day per head.

Oil Content.—On account of the high oil content of cocoanut meal and the unstable character of the oil, the meal will turn rancid if kept in prolonged storage. It is then rather unpalatable to stock, and must be fed in smaller amounts than usual, mixed with other concentrates, as should always be the case. The length of time that cocoanut meal will keep sweet depends both on the water and the oil content of the meal and on the temperature and moisture conditions of the air. There should be no difficulty in keeping cocoanut of good quality sweet and fresh for at least a couple of months.

The fresh meal as ordinarily found on the market contains toward 1 per cent of free fatty acids (on the average, 10 per cent of the total fat), but this percentage is considerably increased when the meal turns rancid, when it may amount to as much as 1.5 per cent of free acids. So far as is known, an increase in the content of free fatty acids is

of no special nutritional importance, except perhaps in case of poultry feeding, but it does affect the palatability of the meal and makes it necessary to feed only moderate amounts in order to have most of the animals eat it.

Effect on Butter and Pork.—Cocoanut meal fed to milk cows tends to produce a hard butter of excellent flavor, and can therefore be combined to advantage with feeding stuffs that have the opposite influence on the butter, like linseed meal, rice feeds, gluten meal, etc. The tendency to produce a hard butter of rather poor texture is especially marked if the cocoanut meal is fed heavily. If fed to hogs, this meal will make a firm pork of good quality; it is therefore of value for counteracting the effect of feeds producing a soft pork, like acorns, peanuts, and those just mentioned.

Aside from the above noted specific effects on the quality of the butter fat, cocoanut meal and a few other feeds of this class have been reported to have a beneficial influence on the milk secretion of cows, causing an increase in the fat content of the milk and also retarding the natural decrease in milk yield due to advancing lactation. Experimental evidence that would substantiate the former claim has been published, especially by European scientists, but on account of the plan and scope of most of these experiments it is doubtful whether they establish conclusively a decided specific effect in the direction mentioned, nor has satisfactory proof of such an effect been furnished from American investigations.

In view of this fact, and because of the present and prospective importance of cocoanut meal to the dairy farmers of the State, it was decided to conduct an experiment in the use of this meal with cows in the dairy herd at the University Farm during the fall of 1919, and to make a careful study both of its effect on the milk secretion of the cows and of its value as a dairy feed in comparison with standard grain mixtures fed by California dairymen.

FIRST FEEDING EXPERIMENT, 1919-1920

Twenty-four cows in the University dairy herd were selected for the experiment, and were separated into three lots as nearly uniform as possible as to breeding, age, body weight, and production of milk and butter fat. The experiment was divided into two periods of six weeks each. A week of preliminary feeding preceded each of these periods, in which the cows received the same feeds as during the subsequent period. The lots were fed concentrates (generally called

“grain” or “grain feed” by farmers), as shown below during the two periods of the experiment.

Period I		Period II	
Lot A.	Regular grain mixture.		Regular grain mixture.
Lot B.	Regular grain mixture plus 2 lbs. of cocoanut meal per head daily.		Regular grain mixture plus 4 lbs. of cocoanut meal per head daily.
Lot C.	Regular grain mixture plus 4 lbs. of cocoanut meal per head daily.		Regular grain mixture plus 2 lbs. of cocoanut meal per head daily.

The grain mixture was composed of the following feeding stuffs: wheat bran, 300 lbs.; rolled barley, 210 lbs.; cottonseed meal, 200 lbs.; and dried beet pulp, 300 lbs. Seven pounds of total concentrates were fed per pound of butter fat produced by the cows, throughout the experiment; of this amount two pounds were therefore cocoanut meal, for Lots B and C during periods I and II, respectively, while four pounds were fed to Lots B and C during periods II and I, respectively, as shown in the table above. Lot A, which was considered a check lot, received the regular grain mixture throughout the experiment. The amount of concentrates fed to each cow was adjusted each week on the basis of her production of butter fat during the preceding week. In addition to the grain rations fed, all cows received alfalfa hay and sweet sorghum silage. All feeds were weighed out to the individual cows twice a day, except the hay, which was weighed out for all the cows once a day and fed in racks in the corral, the amounts being apportioned equally among the cows.

All conditions surrounding the cows were made as uniform as possible, with the exception of the difference in the grain ration noted, and conformed to the regular routine adopted for the care and management of the dairy herd. The milk of the individual cows was weighed at each milking, and composite samples were taken and tested once a week for butter fat and solids (Lactometer method). The cows were weighed on two consecutive days at the beginning and at the close of the experiment, and regularly once a week during its progress. The preliminary feeding commenced October 5, 1919, and the experiment proper commenced on October 15 and was continued for thirteen weeks, till January 14, 1920. The following statement will show the average production of the three lots the week before the experiment commenced, with other data that have a bearing on the production.

AVERAGE DATA FOR EACH LOT AT BEGINNING OF TRIAL

	Lot I	Lot II	Lot III
Age in years and months	4-7	5-10	3-11
Days from last calving	150	175	180
Due to calve in—months	6	6	6
Body weights, in lbs.	1115	1126	1115
Milk yield per day, in lbs.	19.2	18.7	18.6
Butter fat, in lbs.	0.80	0.82	0.80
Average per cent of fat	4.17	4.39	4.30

It will be noted that the average production of butter fat by the cows in the three lots was practically the same, and that other important factors agreed as closely as could be expected with the limited number of cows in the dairy herd from which to choose. The cows included in the experiment were partly pure-bred and partly grade dairy cows, the different lots containing approximately the same number of pure-breds and grades, and of representatives of the various dairy breeds.

The experiment progressed without serious mishaps, except that it became necessary to take out several cows during its progress and substitute others in their places on account of sickness or a marked decrease in their milk flow due to approaching close of the lactation period. When changes became necessary, new cows were placed in the different lots in such a way as to leave the relation between the production of these lots unchanged so far as possible. Six cows in each of Lots A and B, and seven cows in Lot C were kept on the experiment from its beginning to the end. Average data for these cows have been calculated separately, since it was considered that they might furnish more satisfactory results for a study of the specific effects of the cocoanut meal feeding than the data for all the cows included during the whole or a part of the experimental period.

Summary of Results.—The total and average amounts of milk, total solids, and butter fat produced by the cows during the experiment are shown in the following table, which also gives the average daily milk production, the average per cent of solids and butter fat in the milk, and the average body weight of the cows in the various lots.

SUMMARY OF THE RESULTS OF THE FIRST EXPERIMENT, 1919-1920

	Check lot No Cocoanut meal	2 lbs. Cocoanut meal	4 lbs. Cocoanut meal
Total milk produced, lbs.	12899.8	12120.0	11381.8
Total solids, lbs.	1733.6	1688.7	1596.9
Total fat, lbs.	544.45	565.80	548.83
Average per cent solids	13.4	13.9	14.0
Average per cent fat	4.22	4.67	4.82
Average per cent solids not fat*	9.2	9.2	9.2
Average body weights, lbs.	1145	1177	1140
Average production per head daily:			
Milk, lbs.	18.1	17.2	16.3
Solids, lbs.	2.43	2.39	2.25
Butterfat, lb.	.763	.801	.777

* By difference.

It will be noted that the total amount of milk produced by the check lot was 6 per cent higher than that produced by the two other lots when receiving two pounds of cocoanut meal daily, and 12 per cent higher than the amount produced when they received four pounds of cocoanut meal. The production of butter fat resulting from the feeding of two pounds of cocoanut meal, on the other hand, was 3.9 per cent higher than that of the check lot, and that obtained when four pounds of cocoanut meal were fed was 0.8 per cent higher than that of the check lot. The latter difference, at any rate, is too small to be of practical significance.

The reason for the difference in the two sets of figures for production of milk and butter fat is shown to lie in the fact that the milk produced on the cocoanut meal feeding contained a somewhat higher percentage of fat, viz., .45 per cent higher than the check lot for the cows when fed two pounds of cocoanut meal, and .60 per cent higher when four pounds of cocoanut meal were fed. It will be seen that the per cent of solids not fat in the milk remained the same for the different lots throughout the experiment.

In studying the significance of these figures, it should be borne in mind that only the summary results for the two lots fed two and four pounds of cocoanut meal, respectively, are directly comparable. The cows in the check lot were not fed cocoanut meal at any time, and the results of these experiments, therefore, only in a general way furnish information as to the change in the quality of the milk that may result from the feeding of cocoanut meal.

The corresponding data for the cows that were kept on the experiment to the end are shown in the following table:

AVERAGE RESULTS FOR NINETEEN COWS

	Check lot	2 lbs. Cocoanut meal	4 lbs. Cocoanut meal
Average daily production per head:			
Milk, lbs.	18.8	19.7	17.9
Solids, lbs.	2.51	2.74	2.52
Butterfat, lb.	.774	.908	.847
Per cent solids	13.4	13.9	14.1
Per cent fat	4.12	4.61	4.73
Per cent solids not fat*	9.3	9.3	9.4
Average body weight, lbs.	1159	1194	1143

* By difference.

By comparing the production of the cows fed cocoanut meal with that of the check lot fed the regular grain mixture, it will be seen that the average milk yield was somewhat higher for the lots fed two pounds cocoanut meal than for the check lot (an increase of 0.9 pound per head daily, or nearly 5 per cent), and a corresponding decrease occurred when four pounds of cocoanut meal was fed. The light feeding of cocoanut meal, on the other hand, resulted in a gain of 0.134 pound of butter fat per head daily (or about 17 per cent) over that of the check lot; and the heavy cocoanut feeding resulted in a gain against the check lot of only 0.73 pound of butter fat per head daily (or about 91½ per cent).

As in the preceding case, the yields for the four-pound periods were somewhat lower than for the two-pound periods. The improvement in the quality of the milk for the four-pound periods was, however, again greater than for the two-pound periods.

It is important to ascertain how far the effect of the feeding of cocoanut meal noted occurred uniformly for all cows included in Lots B and C. Since a gradual increase in the per cent of fat as a rule occurs with advancing lactation, the results must be studied in view of this fact. In the case of the check lot, the average per cent of fat in the milk of all six cows was .56 higher during Period II than during Period I (ranges .03 to .90). The average for the cows in Lot B was .65 per cent higher in Period II (four pounds cocoanut meal) than in Period I (ranges, .16 to .83 per cent for five cows, the milk of one cow being .49 per cent lower in Period II than during Period I). Turning to Lot C, we find that the feeding of two pounds of cocoanut meal in Period II was likewise accompanied by an improvement in the average quality of the milk, as compared with that produced during Period I (four pounds cocoanut meal), the fat content of the milk of six cows being increased from .10 per cent to 60

per cent, the milk of one cow showing a decrease of .17 per cent in Period II over Period I. The improvement in the average quality of the milk of Lot C during Period II was therefore smaller than that obtained in the case of the two other lots.

While not very conclusive, these results indicate that the feeding of cocoanut meal has a tendency to increase the fat content of the milk, the effect of heavy feeding being more marked than that of light feeding. The plan of the experiment will hardly warrant a more definite statement as to the effect of cocoanut meal on the per cent of fat in the milk. In order to secure more direct evidence on this point, if possible, it was decided to repeat the experiment on a somewhat different plan with other groups of cows in the University dairy herd during the summer of 1920. An account of this second experiment follows the discussion of the present one.

Feed Eaten by the Cows.—The total amounts of feed eaten by the different lots during the experiment are shown in the following table, which also gives the average rations eaten by the cows, and the dry matter and digestible matter contained in them. The chemical analyses were made in the Nutrition Laboratories at Berkeley, through the kindness of Professor M. E. Jaffa, Head of the Division of Nutrition of the University. Average digestion coefficients were assumed in calculating the digestible components of the various feeds and rations.

FEED EATEN BY THE COWS, IN POUNDS

	Check lot No Cocoanut meal	2 lbs. Cocoanut meal	4 lbs. Cocoanut meal
Total amounts of feed eaten:			
Alfalfa hay	18940	18858	19022
Sorghum silage	12264	12726	12313
Grain mixture	3759.2	2648.4	1367.6
Cocoanut meal		1393.0	2631.3
Average rations eaten:			
Alfalfa hay	26.5	26.4	26.6
Sorghum silage	17.2	17.8	17.2
Grain mixture	5.3	3.7	1.9
Cocoanut meal	---	2.0	3.7
Dry matter in ration	32.7	33.0	32.9
Digestible protein	4.18	4.33	4.43
Digestible carbohydrate and fat	14.83	15.28	15.23
Total digestible nutrients	19.01	19.61	19.66
Nutritive ratio, 1:	3.5	3.5	3.4

It will be seen that but slight differences occurred in the average rations eaten by the different lots as regards the amounts of the different feeds, the dry matter, the total digestible nutrients, or the nutritive

ratios. Owing to the large amount of hay and the small amount of silage eaten, the rations were abnormally high in digestible protein, and had a very narrow nutritive ratio, viz., 1:3.5 or 3.4. As this was also the nutritive ratio of the cocoanut meal, it remained the same for the rations containing either two or four pounds of this oil meal.

An examination of the results presented in the table will disclose the fact that the average amount of cocoanut meal eaten during the heavy feeding was 3.7 pounds, and not 4 pounds, as intended. The reason for this is that a few cows refused to eat the full amount. While only two out of seventeen cows did not eat the 2 pounds of cocoanut meal daily, seven failed to eat 4 pounds, the smallest average amount eaten by a cow during the heavy cocoanut meal feeding being 2.7 pounds per day. Our experience suggests that nearly all cows will eat 2 pounds of cocoanut meal daily, but that a considerable number will refuse as much as 4 pounds if they are supplied with a palatable grain mixture along with the oil meal. It is possible that the full amount would have been eaten if the cocoanut meal had been fed wet, as is being done by some farmers, who feed this meal as sole concentrate in large amounts, 5 to 6 pounds or more daily. In the experiments under discussion, however, no special effort was made to induce the cows to eat the entire allowance of cocoanut meal; if they persisted in leaving some of the meal, the daily allowance was reduced by a pound or two, and the regular grain mixture correspondingly increased.

Efficiency of Rations.—By referring to the production of the cows as shown in the table on page 250, and the data for feed consumption given above, we may arrive at the efficiency of the different rations as shown by the amount of dry matter or digestible matter required for the production of one hundred pounds of milk or of one pound of butter fat. The following statement includes the data furnished by the experiment on this point.

RELATIVE EFFICIENCY OF RATIONS

	Check lot	2 lbs. Cocoanut meal	4 lbs. Cocoanut meal
Per 100 lbs. of milk:			
Lbs. dry matter	181	192	202
Lbs. digestible matter	105	114	121
Per lb. of butter fat:			
Lbs. dry matter	42.9	41.2	42.3
Lbs. digestible matter	24.9	24.5	25.3

The results presented in the table show that there was no appreciable difference in the relative economy of feed consumption of the three rations for production of butter fat, while for milk production

the grain rations containing cocoanut meal proved somewhat less efficient than the standard grain ration fed. One pound of butter fat was produced from about twenty-five pounds of digestible nutrients in all three rations; if the amount of milk produced is considered, it will be seen that two pounds of cocoanut meal gave somewhat lower results than the check ration, and four pounds of coanut meal still a little lower. In view of the fact, however, that cocoanut meal is, as a rule, cheaper than a mixed grain ration like the one fed in this experiment (composed of rolled barley, wheat bran, cottonseed meal, and dried beet pulp), the two cocoanut meal rations will be likely to compare favorably in economy for milk production with the ration fed to the check lot; as regards production of butter fat, these rations will be found still more economical than is indicated by the figures given in the table.

We shall now give a brief account of the second experiment with cocoanut meal as a dairy feed, conducted with cows in the University dairy herd during the summer of 1920.

SECOND FEEDING EXPERIMENT, SUMMER OF 1920

This experiment was conducted with similar feeds and under similar conditions as the first experiment. The plan of the second experiment differed from that of the first in that only two lots of cows were selected, which were fed as follows:

Lot A—Period I, regular grain mixture; Period II, grain mixture plus cocoanut meal.

Lot B—Period I, grain mixture plus cocoanut meal; Period II, regular grain mixture only.

Alfalfa hay and silage were fed in addition, to all cows, in amounts similar to those in the first experiment. The grain mixture fed to the whole dairy herd, including the experimental cows, was as follows: Wheat brain, 120 pounds; rolled barley, 140 pounds; dried beet pulp and cottonseed meal, 100 pounds each. The grain was fed in the proportion of 7 pounds per pound of butter fat produced; in the cocoanut meal periods, 2 pounds of the grain allowance were replaced by cocoanut meal for all cows except those fed 6 pounds of total grain or more, which received 3 pounds of cocoanut meal per head daily in the place of a similar amount of the regular grain mixture.

Twelve cows, six in each lot, completed this experiment, which was conducted from April 28 to August 11, 1920, a period of fifteen weeks. As in the preceding experiment, every effort was made to have the two lots of cows as nearly uniform as possible in regard to all factors that influence the production of the cows and the length of the lactation period. The following summary gives the main results obtained

in the experiment as regards the production of milk and milk components.

SUMMARY OF RESULTS—SECOND COCOANUT MEAL EXPERIMENT

	Regular grain mixture	Regular grain mixture plus cocoanut meal
Total milk, lbs.	18772.6	18992.4
Milk solids, lbs.	2334.3	2366.3
Butterfat, lbs.	684.23	702.92
Average body weight of cows, lbs.	1136	1133
Feed eaten, lbs.		
Alfalfa hay	15624	15624
Silage	9152	9152
Grain mixture	4923.4	3133.2
Cocoanut meal		1785.2

The production of milk and butter fat during the periods when the regular grain mixture was given and when cocoanut meal was partially substituted, pound for pound, for this mixture, will be seen from the table. It will be noted that slightly more milk, solids, and butter fat were produced when cocoanut meal was fed as a part of the grain ration than when the regular grain mixture alone was used. The total amounts of feed eaten with the two rations were practically identical, with the exception of the grain feed. The cocoanut meal rations therefore proved somewhat more efficient than those containing the regular grain mixture only. The average body weights of the cows were likewise practically the same for both kinds of rations. All the cows but one increased in weight during the experiment, whichever ration was fed last, the cocoanut meal ration in the case of Lot A or the regular grain mixture in the case of Lot B. The average daily milk yields during the experiment, with average composition of the milk and average rations eaten, may be seen below.

AVERAGE YIELDS OF MILK AND MILK SOLIDS

	Regular grain mixture	Cocoanut meal ration
Average daily milk produced, lbs.	29.8	30.1
Milk solids, lbs.	3.71	3.76
Butter fat, lbs.	1.09	1.11
Average composition of milk, per cent:		
Solids	12.5	12.5
Fat	3.66	3.69
Average rations eaten, lbs.:		
Hay	24.8	24.8
Silage	14.5	14.5
Grain mixture	7.7	5.0
Cocoanut meal		2.8

There was a very slight improvement in the average quality of milk produced during the cocoanut meal periods so far as fat content is concerned. If the data obtained for the individual cows are scanned, it is found that five cows in Lot A, on going from the regular grain mixture to cocoanut meal, increased from .15 per cent to .49 per cent in the average fat content of the milk, and one cow decreased .20 per cent (average increase for the lot, .19 per cent). In the case of four cows in Lot B, the fat content was higher on the cocoanut meal feeding during Period I than on the regular grain mixture feeding during Period II by .01 per cent to .31 per cent, the milk of two cows in Period II being, respectively, .06 per cent and .19 per cent lower in fat content than in Period I (average increase for lot, .01 per cent). The regular grain mixture was therefore unable to maintain the fat percentage of the preceding cocoanut meal feeding. The improvement in percentage fat content resulting from, or coincident with the feeding of cocoanut meal, in only four cases out of twelve amounted to more than .3 per cent, and on the average for all cows the fat content was increased only .03 per cent.

While the changes given are, in most cases, too slight to be of much practical importance, it will be noted that they are, in the great majority of cases, in favor of the cocoanut meal feeding, and the results obtained in early American and European experiments in regard to the influence of this oil meal on milk production, as well as in the experiment previously referred to, are therefore corroborated.⁶

The quality of the milk produced by a cow does not vary greatly under normal conditions if sufficient feed is supplied to maintain normal body functions and an even body weight. Contrary to the opinion of many dairymen, it is not as a rule possible to change permanently in a marked manner the per cent of fat in the milk by any definite system of feeding, or by the use of special feeds. An apparent exception to this rule is furnished by a few feeds especially high in fats, and the results obtained in the two experiments described and in other experiments have shown that cocoanut meal is one of these feeds. Palmnut meal, molasses, and malt sprouts have also been found to exert a similar beneficial influence on the fat content of the milk, although the evidence at hand with regard to the last mentioned feed can hardly be considered conclusive—a matter which, however, is no longer of importance in view of the disappearance of this feed from the market.

⁶ See Mass. Exp. Sta. Bulletin 155, pp. 188–189, July, 1914; Fingerling, Landw. Versuchs Stationen 62, p. 11; 71, p. 273; Morgen, *ibid.*, 77, p. 20; Hansen, Landw. Jahrb. 35, p. 125; Jour. Southeast Agr. College, Wye., Sept., 1911, p. 45.

The feeding of cocoanut meal in the experiment under discussion was beneficial also as regards the quantity of milk produced. The average yield of milk for Lot A was five pounds lower than the yield on the regular grain mixture, and in the case of Lot B there was an average loss in daily milk yield of 6.2 pounds daily, on going from cocoanut meal to the grain mixture. In the case of Lot A there was a decrease of only 231.1 pounds (16 per cent) from the first week of Period I (grain mixture) to the last week of Period II (cocoanut meal), against a decrease of 414.3 pounds (28 per cent) during the same time with the feeds reversed. This indicates that the statement previously made as regards the tendency of cocoanut meal to decrease the natural falling-off in milk flow due to the progress of the lactation, is correct. The influence of the cocoanut meal in dairy rations may therefore be considered beneficial, both as regards the flow of milk and its quality. It will be remembered that in the experiments described, the cocoanut meal was introduced as part of and compared with common grain rations fed by dairymen in this State, which are composed of barley, wheat bran, cottonseed meal, and dried beet pulp. The rations of cocoanut meal and mixed grain feeds therefore proved not only equal, but somewhat superior to these standard mixtures for milk production. Furthermore, in view of the fact that cocoanut meal is ordinarily considerably cheaper than these mixtures on our feed market and cheaper than any of the components of the mixtures except cottonseed meal (see page 246), there is every reason to take advantage of the situation and to use this oil meal as a component part of the grain rations for dairy cows.

COCOANUT MEAL FOR OTHER CLASSES OF FARM ANIMALS

Swine.—Cocoanut meal is frequently fed to fattening hogs in this State, being generally mixed with barley or other hog feeds. In experiments conducted by Thompson and Voorhies at the University Farm, ground barley and cocoanut meal placed in self-feeders were found more economical than ground barley fed alone. Cocoanut meal proved to be a suitable substitute for barley in feeding market hogs, if given in the proportion of one part to three or four parts of barley, by weight. A larger proportion of the meal proved too laxative when fed in conjunction with alfalfa pasture or cut green alfalfa.

Poultry.—Cocoanut meal is used largely as a component of commercial poultry feeds in mixtures with other concentrates. In the aggregate, considerable quantities of this oil meal is thus used in the poultry sections of the State. Such investigational work as has been conducted with cocoanut meal by the Poultry Division of the College of Agriculture up to the present time indicates that it is not quite so

palatable or so beneficial physically to poultry as soybean meal or linseed meal, but that it is a reasonably good high-protein feed and as valuable in proportion to its protein content as other oil meals.

Other Farm Animals.—The use of cocoanut meal as a substitute for oats in feeding army and work horses has been previously referred to. It may also be fed with advantage to fattening steers and, in small amounts, to calves and sheep.⁷ In the case of all these classes of farm animals it should be fed mixed with other concentrates, which, as we have seen, is, generally speaking, the best method of feeding all oil meals.

Aside from the beneficial influence of cocoanut meal on milk production, which is evidenced by the results of the experiments discussed or referred to in this bulletin, there are other good reasons for including it in dairy rations or rations for farm animals in general. The available feed supply in this State is composed of relatively few feeding stuffs, and cocoanut meal furnishes a valuable addition to the list. It comes from a different source from that of any other feed on the market, thus giving dairy farmers the benefit of more competition among dealers and a greater variety of feeds from which to select the concentrates required in their feeding operations. The latter point is of special importance in the feeding of high-producing animals, since supplying a variety of feeding stuffs aids in maintaining a keen appetite and a large production, and contributes to good general health and thriftiness. A variety of feeds is also more likely to furnish all the essential elements of organic and mineral substances necessary for normal production and for the exercise of the vital functions than can be obtained from single feeds or feeds of only two or three different plant sources. It is therefore recommended to include cocoanut meal in the rations, not to the exclusion of standard feeds, but in addition to them, when it can be obtained at a reasonable cost compared with that of other concentrates, i.e., at a price warranted by its actual nutritive value, as has heretofore invariably been the case.

Cocoanut meal, under ordinary feeding practices, may be considered somewhat below cottonseed meal or linseed meal in feeding value, and above wheat bran, dried beet pulp, or molasses. It will, generally speaking, approximate more closely to barley and other cereals in feeding value than to any other class of feeding stuffs, and, as suggested, can ordinarily be bought at a lower price than either this class of feeds or the mill feeds. By including cocoanut meal in the rations of dairy cows and other farm animals, a decrease in the cost of production may therefore be confidently expected.

⁷ California Exp. Station Report, 1919, p. 78.